United States
Department of
Agriculture

Forest Service

Forest
Products
Laboratory

DIVIDENDS FROM WOOD RESEARCH

Recent Publications

January—June 1987

instruction and explanation

"Dividends From Wood Research" is a semiannual listing of recent publications resulting from wood utilization research at the Forest Products Laboratory (FPL). These publications are produced to encourage and facilitate application of Forest Service research. This issue lists publications received from the printer by the FPL Publications Section between January 1, 1987, and June 30, 1987.

Each publication listed in this brochure is available through at least one of the sources below. For each entry in the brochure, we indicate the primary source for that publication and show you how to obtain a copy:

Available from FPL (indicated by an order number before the title of the publication): Quantities limited. Circle the order number on the blank at the end of the brochure and mail the blank to FPL.

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list of categories

Publications are listed in this brochure within the following general categories:

Biodeterioration and protection
Chemicals from wood
Engineering properties and design criteria
General
Microbial and biochemical technology
Mycology
Processing of wood products
Pulp, paper, and packaging
Structural fiber and particle products
Timber requirements and economics
Tropical wood utilization
Wood bonding systems

biodeterioration and protection

1. Looking Back at 75 Years of Research in Wood Preservation at the U.S. Forest Products Laboratory
Baechler, Roy H.; Gjovik, Lee R.
In: Proceedings, 82d annual meeting American Wood-Preservers' Association, vol. 82; 1986 April 27-30; Philadelphia, PA. Stevensville, MD: American Wood-Preservers' Assoc.; 1986: 133-149.

This paper deals mainly with research at the Forest Products Laboratory. There will be limited references to the literature. It is assumed that the reader has access to the AWPA Proceedings, and most of the references to papers published in other journals.

2. Weathering and Decay of Finished Aspen Waferboard

Carll, Charles G.; Feist, William C.
Forest Prod. J. 37(4): 27-30; 1987.

Specimens of commercial aspen waferboard were prepared with six different "pretreatments" (no pretreatment and five different pretreatments) and finished with four different finishing systems (latex stain, oil stain, acrylic latex primer plus acrylic latex paint, and alkyd primer plus acrylic latex paint). These specimens were exposed outdoors in Wisconsin, Mississippi, and Washington State. Horizontal panel edges were protected. Vertical edges were butted against wood strips, and hence these joints were not waterproof.

Research to Protect Wood

De Groot, R. C.
In: Crowley, John J., ed. 1986 Yearbook of agriculture, research for tomorrow. 1986: 233-235. (Available from Superintendent of Documents, Government Printing Office, Washington, DC 20402-9325; $10.)

In this chapter the author discusses research trends in wood protection. Reducing wood loss from decay, the significance in drying wood, and new technologies in preservative wood treatments are described.

3. Weathering Performance of Finished Yellow-Poplar Siding

Feist, William C.
Forest Prod. J. 37(3): 15-22; 1987.

The primary objective of this study was to obtain information and develop an understanding of the weathering performance of representative top-quality currently available finishing systems on yellow-poplar (*Liriodendron tulipifera*). Yellow-poplar is a medium density, diffuse porous hardwood with a moderate resistance to weathering that should make it an attractive wood for use in outdoor applications. The finishes included in this study represented commercial and laboratory preparations. The effects of pretreatment/primer/finish/substrate interactions were emphasized.

4. Weathering Behavior of Dimensionally Stabilized Wood Treated by Heating Under Pressure of Nitrogen Gas

Feist, William C.; Sell, Juergen
Wood Fiber Sci. 19(2): 183-195; 1987.

With the goal of improving the weathering behavior of wood by reducing its hygroscopicity and accompanying dimensional changes, samples of spruce and beech were heat-treated under nitrogen pressure at 175 to 195°C and subjected to natural and artificial weathering. Beech had a significantly lower hygroscopicity and improved dimensional stability after heat treatment and was more resistant to weathering than the unheated control. Although the hygroscopicity of spruce was also significantly reduced by heat treatment, weathering resistance was diminished. Heat treatment of either species had small, but measurable effects on the performance and durability of semitransparent and film-forming stains applied to the samples.

5. Micromorphology of Degradation in Western Hemlock and Sweetgum by the White-Rot Fungus *Coriolus versicolor*

Highley, Terry L.; Murmanis, Lidija L.
Holzforschung. 41(2): 67-71; 1987.

The micromorphological changes in sweetgum and western hemlock sawdust caused by the white-rot fungus *Coriolus versicolor* were studied by transmission electron microscopy (TEM). Degradation by *C. versicolor* differed in sweetgum and hemlock. Sweetgum was attacked by hyphae from both the lumen and the cell corners. Hemlock was attacked only from the lumen. The compound middle lamella of hemlock was not attacked until removal of the secondary wall was completed; the cell corners were particularly resistant to degradation.

6. Fifteen-Year Test of In-Place Treatments for Control of Decay in Waterfront Structures

Highley, Terry L.; Scheffer, Theodore
Mater. Org. 21(3): 181-190; 1986.

This paper reports the 15-year results of experiments established in 1969 to determine the potential of (a) in-place treatment of deck planking with fungicides for controlling decay in untreated wood or pressure-treated wood having checks that penetrate the zone of preservative treatment and (b) cap and fungicidal treatment for protecting from decay the cut tops of newly installed piles.

7. Soft Rot of Preservative-Treated Southern Pine in a Marine Environment

Johnson, Bruce R.; Eslyn, Wallace E.
In: Proceedings, 82d annual meeting American Wood-Preservers' Association, vol. 82; 1986 April 27-30; Philadelphia, PA. Stevensville, MD: American Wood-Preservers' Assoc.; 1986: 150-158.

Substantial quantities of treated, sawn southern pine lumber and timber are installed in marinas and along waterfronts as sheet piling. Commodity standards do not restrict the amount of heartwood at or near the surface of such lumber and timber. This report presents evidence that marine soft-rot fungi can degrade preservative-treated southern pine, and raises the concern that such erosion could expose untreated wood to marine borer attack.

8. *Sphaeroma terebrans* Bate: A Note on Distribution and Preservative Tolerance in Florida Coastal Waters

Johnson, Bruce R.; Estevez, Ernest D.; Rice, Stanley A.
Document IRG/WP/4135. Stockholm, Sweden: The International Research Group on Wood Preservation Secretariat; 1987. 6 p.

Treated test panels were installed in January 1984 in a Florida estuary where *Sphaeroma terebrans* had severely damaged pilings treated with copper chromate arsenate (CCA). Test treatments were CCA at three retentions, coal-tar creosote at three retentions, creosote with chlorpyrifos, dual treatment with CCA and creosote, and three types of chemical modification of the wood test panels. We describe the condition of the panels after 3 years exposure in the intertidal zone. Results of a 1985-86 survey are summarized, showing that this borer is common in Florida estuaries along the Atlantic and Gulf coasts.

9. Cytochemical Localization of Cellulases in Decayed and Nondecayed Wood

Murmanis, L.; Highley, T. L.; Palmer, J. G.
Wood Sci. Technol. 21: 101-109; 1987.

Enzyme assay showed that the commercial cellulase from *Trichoderma reesei* degraded several polysaccharide substrates; highest activity was on xylan. Transmission electron micrographs showed that the *T. reesei* cellulase degraded nondecayed wood extensively; the attack always progressed from the point of contact into the cell wall. Cytochemically prepared wood that had been decayed by *Poria placenta* showed uniform distribution of electron-dense particles throughout the walls; the same results were observed with added *T. reesei* cellulase. In wood decayed by *Ganoderma applanatum* without or with added *T. reesei* cellulase, the progress of degradation was similar to that in nondecayed wood.

10. Nondestructive Stress Wave Measurements of Decay and Termite Attack in Experimental Wood Units

Pellerin, Roy F.; DeGroot, Rodney C.; Esenther, Glenn R.
In: Pellerin, Roy F.; McDonald, Kent A., cochair. Proceedings, 5th Nondestructive Testing of Wood Symposium; 1985 September 9-11; Pullman, WA. Pullman, WA: Washington State University; 1986: 319-352.

This report presents the results of longitudinal stress wave analysis of wood material exposed to brown-rot decay fungi (*Gloeophyllum trabeum*) and of wood material exposed to various degrees of attack by subterranean termites.

Assessment of Preservative Treated Aspen Waferboard After 30 Months of Field Exposure

Schmidt, Elmer L.; Hall, Henry J.; Gertjejansen, Roland O.; Carll, Charles G.
Forest Prod. J. 37(2): 62-66; 1987. (Available from Elmer L. Schmidt, Dept. of Forest Products, University of Minnesota, St. Paul, MN 55108. No charge.)

Extensive laboratory tests were conducted to determine the effects of various wood preservatives on the mechanical and thickness swelling properties as well as associated biodeterioration and strength reductions in aspen waferboard. The better-performing treatments were tested in outdoor exposure plots at the Harrison Experimental Forest, Gulfport, Miss., and the University of Minnesota, St. Paul, Minn. After 30 months of exposure, visual observations were made of the extent of degradation, fungi were isolated to generally assess taxa growing on or within the panels, and mechanical testing was performed to compare residual strength values among treatment types. These field exposure data were also needed to verify the ability of laboratory evaluations to predict preservative performance.

11. Acid Effects on Accelerated Wood Weathering

Williams, R. Sam
Forest Prod. J. 37(2): 37-38; 1987.

In this preliminary study, the author reports the effect of dilute mineral acid on the springwood erosion rate during accelerated weathering. Exposure of wood strips during winter caused a higher than expected loss in tensile strength. This loss was attributed to acid rain. Also reported was loss of tensile strength of thin strips of wood soaked in dilute acid.

chemicals from wood

12. An Engineering Analysis of the Production of Xylose by Dilute Acid Hydrolysis of Hardwood Hemicellulose

Maloney, Mark T.; Chapman, Thomas W.; Baker, Andrew J.
Biotechnol. Prog. 2(4): 192-202; 1986.

Numerical simulations of various reactors for the production of xylose from hardwood hemicellulose by dilute sulfuric acid hydrolysis have been developed to analyze the effects on reactor performance of heat and mass transfer as well as reaction kinetics. An economic objective function representing the incremental cost of producing a 10 percent xylose solution for fermentation to ethanol was calculated from the results of the reactor simulations to identify the operating conditions that minimize production costs for each reactor type. Lower production costs were estimated for percolation and continuous counter-current reactors; the cost for xylose production in a continuous co-current reactor is significantly higher. Production of ethanol from hardwood hemicellulose is not economical with any of the reactors considered, but the models developed here may be used to analyze other process alternatives for use of hemicellulose via production of xylose.

13. Quantitative ^{13}C NMR of Lignins – Methoxyl:Aryl Ratio

Obst, John R.; Landucci, Lawrence L.
Holzforschung. 40(Suppl.): 87-92; 1986.

A ^{13}C nuclear magnetic resonance method was used to determine the methoxyl:aryl ratios of softwood and hardwood lignins, and to calculate the syringyl:guaiacyl ratio of hardwood lignins. The data indicate that the middle lamella lignin of hardwoods is a syringyl-guaiacyl copolymer. However, there were quantitative differences among species: white birch and sweetgum appeared to have guaiacyl-rich middle lamella lignin and syringyl-rich fiber cell wall lignin, whereas red oak and American elm had a more uniform syringyl-guaiacyl distribution. The morphological origin of milled wood lignin is also discussed.

Effect of Flooding on Growth, Stem Anatomy, and Ethylene Production of *Pinus halepensis* Seedlings

Yamamoto, F.; Kozlowski, T. T.; Wolter, K. E.
Can. J. For. Res. 17: 69-79; 1987. (Available from T. T. Kozlowski, Room 3206, Phelps Hall, University of California, Santa Barbara, CA 93106. No charge.)

Flooding of soil for 43 days greatly altered growth and stem anatomy and increased ethylene production by stems of 10-month-old *Pinus halepensis* seedlings. Data indicated an important regulatory role of ethylene in altering growth and stem anatomy of woody plants.

14. Naval Stores Research at the Forest Products Laboratory, Past and Present

Zinkel, Duane F.
Naval Stores Rev. 97(1): 5-8; 1987.

The author provides a brief review of the naval stores program at the Forest Products Laboratory. An indication of the range of this research is reflected in a selection of publications listed at the end of this paper. (A complete list of FPL naval stores-related publications can be obtained from the author.)

15. Diterpene Resin Acids from the Needle Oleoresin of *Pinus strobus*

Zinkel, Duane F.; Magee, Thomas V.
Phytochem. 26(3): 769-774; 1987.

The resin acid components of *P. strobus* needles were isolated, and the major constituents identified as labdenoic diterpenes. In addition to anticopalic and strobic acids previously reported in the needles, 3-oxoanticopalic, 3β-acetoxyanticopalic, 3β-hydroxyanticopalic acids and the 8α-hydroxy derivative of anticopalic acid were found along with two new compounds. The structures of the two new compounds, a cycloanticopalic acid and an abeoanticopalic acid, were determined by NMR. The composition of the diterpene resin acids was obtained for several samples of *P. strobus* needles from provenance tests.

engineering properties and design criteria

Mechanical Fastener Performance in Reconstituted Structural Wood-Base Panel Products: Problem II – Direct Withdrawal and Fastener Head Pull-Through Performance of Selected New Commercial Structural Wood-Base Sheathing Panel Materials

Chow, Poo; McNatt, J. Dobbin; Gertner, George; Lambrechts, Steve
Special Issue No. 1; 1986. 53 p. (Available from Department of Forestry, Illinois Agricultural Experiment Station, University of Illinois, Urbana, IL 61801. No charge.)

The main objective of this study was to develop information on the direct fastener withdrawal and fastener head pull-through resistance in new structural wood-base sheathing and siding panel products compared to conventional plywood sheathing materials.

Dynamic Characteristics of Wood and Gypsum Diaphragms

Falk, R. H.; Itani, R. Y.
J. Struct. Eng. 113(6): 1357-1370; 1987. (Available from American Society of Civil Engineers, 345 East 47th Street, New York, NY 10017-2398. Cost $1.00 as paper No. 21603.)

Wood diaphragms resist lateral forces in wood frame buildings and efficiently absorb the energy produced by wind and earthquakes. The dynamic characteristics of 10 plywood- and gypsum-sheathed diaphragms were determined by full scale tests. Results are presented in the form of natural frequencies and camping ratios.

16. A Cumulative Damage Model to Predict Load Duration Characteristics of Lumber

Gerhards, C. C.; Link, C. L.
Wood Fiber Sci. 19(2): 147-164; 1987.

Current wood engineering design methods use adjustment factors for different end use conditions. These factors are not flexible enough to account for the effects of different load histories (duration of load) on the reliability of wood structures. Such flexibility can be provided by a cumulative damage model. This study was undertaken to evaluate a previously proposed cumulative damage model, using time-to-failure data from two different types of load histories (ramp loading and constant loading) for Douglas-fir 2 by 4 lumber containing an edge knot. A preliminary evaluation of this research was presented at the 1983 IUFRO Division 5 Conference.

Field Measurements of Seasonal Wood Moisture Variations in Residential Attics

Harrje, D.; Dutt, G. S.; Gibson, R. G.; Jacobson, D. I.; Hans, G.
In: Thermal Performance of the Exterior Envelopes of Buildings III; 1985 December 2-5; Clearwater Beach, FL. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.; 1986: 620-633. (Available from ASHRAE, 1791 Tullie Circle, NE, Atlanta, GA 30329; $4.)

Experimental studies are described on the seasonal variation in wood moisture content in two New Jersey attics. The attic wood adsorption/desorption rate averaged over a season was found to make a small but noticeable contribution to the total attic moisture balance, which is dominated by airflow to and from the attic.

17. Assessment of Truss Plate Performance Model Applied to Southern Pine Truss Joints

McCarthy, Monica; Wolfe, Ronald W.
USDA Forest Serv. Res. Pap. FPL-RP-483; 1987. 13 p.

As part of the Canada-U.S.A. cooperative research program to model the stiffness and strength of residential roof systems, nonlinear model parameters were determined to characterize the lateral resistance of southern pine truss-plated joints. Four standard configurations were tested and used to predict joint performance at varying orientations of plate and grain to load. Two nonstandard configurations were tested to check the accuracy of the transformation methods.

18. Localized Slope-of-Grain—Its Importance and Measurement

McDonald, Kent; Bendtsen, B. Alan
In: Pellerin, Roy F.; McDonald, Kent A., co-chair. Proceedings, 5th nondestructive testing of wood symposium; 1985 September 9-11; Pullman, WA. Pullman, WA: Washington State University; 1986: 477-489.

Present stress rating assignments to structural lumber are accomplished by either visual, or a combination of machine and visual, assessments of the inherent strength and stiffness of individual pieces. Visual assessments of lumber strength and stiffness are based on strength limiters such as the size, location, and frequency of knots and the general slope-of-grain. The visual override portion of the present machine stress rating procedure also includes this visual assessment. Localized slope-of-grain is an important strength reducing characteristic which is not considered in these visual assessments. This paper reports on evaluations of a method to obtain an accurate measurement of the localized slope-of-grain.

19. Light-Frame Construction Research at USDA Forest Products Laboratory—A Status Report

Moody, Russell C.; Sherwood, Gerald E.
Applied Eng. Agric. 2(2): 167-173; 1986.

USDA Forest Products Laboratory research aimed at improved performance of structural components and more effective use of wood for light-frame construction is described. In addition, dissemination of research results through in-house publications and technology transfer is discussed.

Fifth Nondestructive Testing of Wood Symposium

Pellerin, Roy F.; McDonald, Kent A.
In: Proceedings, Fifth nondestructive testing of wood symposium; 1985 September 9-11; Washington State University, Pullman, WA. Pullman, WA: Washington State University; 1986. (Available from Washington State University, Conferences and Institutes, 138 Dana Hall, Pullman, WA 99164-2712. Cost $40.)

Highlights of the five sessions of the Fifth Nondestructive Testing of Wood (NDT) Symposium are presented. Topics discussed include NDT of wood applications in trees, logs, poles, lumber, plywood, reconstituted wood, parallel laminated veneer, existing wooden structures, and relating market requirements to quality assurance procedures.

20. Effect of Length on Tensile Strength in Structural Lumber

Showalter, K. L.; Woeste, F. E.; Bendtsen, B. A.
USDA Forest Serv. Res. Pap. FPL-RP-482; 1987. 9 p.

This report is the first published attempt to link the lengthwise stochastic variation of modulus of elasticity (MOE) in a single board to the board's tensile strength. The modeling method is applicable to research on truss design, glulam applications, and lumber grading, after acquisition of the additional information or refinement of the present model needed for these applications.

21. Angle to Grain Strength of Dowel-Type Fasteners

Soltis, Lawrence A.; Karnasudirdja, Suparman; Little, James K.
Wood Fiber Sci. 19(1): 68-80; 1987.

Timber structures require adequate connections between components. Connection design is based on the performance criterion of a single fastener. This study is part of a research effort by the Forest Products Laboratory to establish a common basis design criteria for lateral strength of dowel-type fasteners that includes nails, screws, lag screws, and bolts. A general dowel lateral strength model is determined. It depends on specific gravity, dowel diameter, minimum penetration, and load direction to the angle of grain. The model is then used to determine the diameter at which parallel- and perpendicular-to-grain strength becomes unequal. A nail model is also determined and compared to existing models.

22. Strength and Ductility of Sheathed Walls

Soltis, Lawrence A.; Patton-Mallory, Marcia
In: Proceedings, 8th European conference on earthquake engineering, 4; Lisboa, Portugal: Laboratorio Nacional de Engenharia Civil; 1986: 7.6/57-7.6/63.

Plywood- and gypsum-sheathed shear walls resist seismic lateral forces in timber-framed buildings. This report gives strength and ductility data from tests of 200 small-scale walls. Both one- and two-sided sheathing of plywood and gypsum and four aspect ratios (length to height of wall) were tested. Results indicate both plywood and gypsum shear walls have strength proportional to wall length and a constant ductility. Gypsum walls have significant strength and ductility.

23. Bolted-Connection Design

Soltis, Lawrence A.; Wilkinson, Thomas Lee
USDA Forest Serv. Gen. Tech. Rep. FPL-GTR-54; 1987. 21 p.

Recent failures of bolted connections have raised doubts about our knowledge of their design. Some of the design criteria are based on research conducted more than 50 years ago. This paper compares results found in the literature, using the European Yield theory as a basis of comparison, to summarize what is known about bolted-connection design and what needs further research. By putting all this information in one place we hope to help engineers and architects design safer timber buildings and structures.

Inspection of Wood Beams and Trusses

U.S. Navy
NAVFAC MO-111.1. Alexandria, VA: Naval Facilities Engineering Command; 1985 September. (Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; $13.95; Order No. PB87 172177/AS.)

This Maintenance and Operations (MO) Manual for Facility Condition Evaluation Standards prescribes the procedures for identifying and evaluating the deficiencies in timber trusses and laminated wood arches. This manual first defines the types of deterioration and lists the underlying causes of these deficiencies. A rating system is developed, based on the urgency of action required at the level of the public works engineering staff. Inspection equipment and procedures are then explained. There are separate chapters of Condition Evaluation Standards for timber trusses and laminated wood arches. The various condition ratings are explained and many are illustrated. An inspection format is suggested for each type of structure.

Nail-Slip in Wood-Joist Floors

Wheat, D. L.; Shock, D. C.; Wolf, L. M.
Forest Prod. J. 36(11/12): 29-32; 1986. (Available from Forest Products Research Society, 2801 Marshall Court, Madison, WI 53705. Cost $2 each, with $5 minimum, plus 10 percent postage and handling.)

Wood joist floor systems resist loads through partial composite action between the sheathing and floor joists with the degree of composite action depending on the stiffness of the nailed joints. In this study, the slip (or deformation) at the nailed joints in 12 different floors was measured and forces were calculated based on known joint behavior. At normal design loads, the forces were found to be within allowable values and slip values below the commonly accepted value for proportional limit.

general

24. Better Recovery, Better Products

Erickson, John R.
In: Youngs, Robert, coordinator. Proceedings of the 18th IUFRO World Congress, Division 5, Forest Products; 1986 September 7-21; Ljubljana, Yugoslavia. Yugoslav IUFRO World Congress Organizing Committee; 1986: 445-456.

The author first provides a broad overview of the timber supply in temperate forests and the demands on these resources. He then discusses the progress toward better utilization, including the increased use of residues, and gives examples of research leading to better recovery and better products.

25. Education of Engineers on Structural Use of Wood

Moody, R. C.; Freas, A. D.
In: White, Julia L., ed. Wood markets: Alternatives to residential construction: Proceedings 47347; 1985 November 18-20; Portland, OR. Madison, WI: Forest Prod. Res. Soc.; 1987: 25-31.

The paper examines the present situation and the role that different organizations play in the education of engineers regarding timber design. Universities are expected to provide the basic education and, in the timber structures area, some do at the undergraduate and graduate levels. Also, some offer continuing education courses on timber design.

microbial and biochemical technology

26. Oxidation of Polycyclic Aromatic Hydrocarbons and Dibenzo[*p*]-dioxins by *Phanerochaete chrysosporium* Ligninase

Hammel, Kenneth E.; Kalyanaraman, B.; Kirk, T. Kent
J. Biol. Chem. 261(36): 16948-16952; 1986.

The lignin peroxidase (ligninase) of *Phanerochaete chrysosporium* catalyzes the oxidation of a variety of lignin-related compounds. The authors report that this enzyme also catalyzes the oxidation of certain aromatic pollutants and compounds related to them, including polycyclic aromatic hydrocarbons with ionization potentials $\leq \sim 7.55$ eV. This result demonstrates that the H_2O_2-oxidized states of lignin peroxidase are more oxidizing than the analogous states of classical peroxidases. Experiments with pyrene as the substrate showed that pyrene-1,6-dione and pyrene-1,8-dione are the major oxidation products (84 pct of total as determined by high performance liquid chromatography), and gas chromatography/mass spectrometry analysis of ligninase-catalyzed pyrene oxidations done in the presence of $H_2{}^{18}O$ showed that the quinone oxygens come from water.

27. Effect of Light and Aeration on Fruiting of *Lentinula edodes*

Leatham, Gary F.; Stahmann, Mark A.
Trans. Br. Mycol. Soc. 88(1): 9-20; 1987.

The authors report that light and aeration are essential for the fruiting of *L. edodes*. The nature of the light and aeration requirements, the receptive stages of the life-cycle, and the marked effects of medium composition are discussed.

28. Batch and Membrane-Assisted Cell Recycling in Ethanol Production by *Candida shehatae*

Sreenath, Hassan K.; Jeffries, Thomas W.
Biotechnol. Letters. 9(4): 293-298; 1987.

During xylose fermentation by *Candida shehatae* ATCC 22984 with batch cell recycling, the volumetric ethanol fermentation rate increased two-fold, and the xylitol production rate increased three-fold as the cell density increased to ten-fold. In continuous fermentation with membrane-assisted cell recycle, the fermentation rates increased almost linearly with increasing agitation rates up to 300 rpm.

29. Selection and Improvement of Lignin-Degrading Microorganisms: Potential Strategy Based on Lignin Model-Amino Acid Adducts

Tien, Ming; Kersten, Philip J.; Kirk, T. Kent
Appl. Environ. Microbiol. 53(2): 242-245; 1987.

The purpose of this investigation was to test a potential strategy for the ligninase-dependent selection of lignin-degrading microorganisms. The strategy involves covalently bonding amino acids to lignin model compounds in such a way that ligninase-catalyzed cleavage of the models releases the amino acids for growth nitrogen. Here we describe the synthesis of glycine-***N***-2-(3,4-dimethoxyphenyl)ethane-2-ol (I) and demonstrate that growth (as measured by mycelial nitrogen content) of the known lignin-degrading basidiomycete *Phanerochaete chrysosporium* Burds. with compound I as the nitrogen source depends on its production of ligninase. Ligninase is shown to catalyze the oxidative C—C cleavage of compound I, releasing glycine, formaldehyde, and veratraldehyde at a 1:1:1 stoichiometry. *P. chrysosporium* utilizes compound I as a nitrogen source, but only after the cultures enter secondary metabolism (day 3 of growth), at which time the ligninase and the other components of the ligninolytic system (lignin→ CO_2) are expressed. Compound I and related adducts have potential not only in the isolation of lignin-degrading microbes but, perhaps of equal importance, in strain improvement.

mycology

Distribution of Active Ectomycorrhizal Short Roots in Forest Soils of the Inland Northwest: Effects of Site and Disturbance

Harvey, Alan E.; Jurgensen, Martin F.; Larsen, Michael J.; Schlieter, Joyce A.
USDA Forest Serv. Intermountain Res. Stn. Res. Pap. INT-374; 1986. 8 p. (Available from Intermountain Research Station, Federal Building, 324 25th St., Ogden, UT 84401. No charge.)

This study investigates the involvement of surface soil components in ectomycorrhizal processes over (1) a wide range of mature ecosystems (habitat types) distributed throughout the Inland Northwest and (2) a range of site disturbance types within a local geographical area on similar habitat types.

Relationships Among Soil Microsite, Ectomycorrhizae, and Natural Conifer Regeneration of Old-Growth Forests in Western Montana

Harvey, A. E.; Jurgensen, M. F.; Larsen, M. J.; Graham, R. T.
Can. J. Forest Res. 17: 58-62; 1987. (Available from Dr. M. F. Jurgensen, Department of Forestry and Wood Production, Michigan Technological University, Houghton, MI 49930. No charge.)

Successful establishment, root distribution, growth, and ectomycorrhizal development of conifer regeneration in three old-growth forests in western Montana showed site-specific associations with soil microsites containing organic matter. A positive association between decayed wood in the soil and establishment of seedlings occurred on the two drier sites. In general, organic soil components supported most of the root system and ectomycorrhizae on all three sites.

Timber Harvesting, Soil Organic Matter, and Site Productivity

Jurgensen, M. F.; Larsen, M. J.; Mroz, G. D.; Harvey, A. E. In: Smith, C. Tattersall; Martin, C. Wayne; Tritton, Louise M., eds. Proceedings, 1986 Symposium on the Productivity of Northern Forests Following Biomass Harvesting; 1986 May 1-2; Durham, NH. Gen. Tech. Rep. NE-GTR-115. Broomall, PA: U.S. Department of Agriculture, Forest Service; 1986: 43-52. (Available from Dr. M. F. Jurgensen, Department of Forestry and Wood Production, Michigan Technological University, Houghton, MI 49930. No charge.)

Soil organic matter is important for the maintenance of forest site productivity. Recent studies of eastern forests have shown organic matter reductions in both the forest floor and mineral soil following cutting and site preparation. Although reduced soil organic content may affect soil chemical, physical and biological properties, most concerns have been on possible nutrient losses or changes in nutrient availability. Little is known about the effects of decreased organic content on other soil properties such as water retention, structure, and cation exchange capacity.

30. *Lindtneria thujatsugina* sp. nov. (Stephanosporales, Stephanosporaceae) and Notes on Other Resupinate Basidiomycetes with Ornamented Basidiospores

Larsen, Michael J.
Nova Hedwigia. 43: 255-267; 1986.

A new species, *Lindtneria thujatsugina*, is described. The unique morphology of the basidiospore in the Stephanosporaceae is further clarified through brightfield and scanning electron microscopy. *Lindtneria trachyspora* is lectotypified and the taxonomic positions of *Serpula rugospora*, *Lindtneria pellicularis* and *Poria baboquivariensis* are re-evaluated. *Lindtneria rugospora* is proposed as a new combination.

processing of wood products

31. High-Temperature Drying of Southern Pine 2 by 4's: Effects on Strength and Load Duration in Bending

Gerhards, C. C.
Wood Sci. Technol. 20: 349-360; 1986.

Southern pine lumber specimens dried by conventional (82°C maximum) and high temperature (116°C for less than 1 day) schedules were tested to determine if high-temperature drying affects load duration. Results show that high-temperature drying has no appreciable effect on load duration, probably because it has no appreciable effect on static strength. Results from combining the data from both kinds of drying suggest that the load duration effect is less severe for lumber than for small clear specimens.

32. Laser Incising to Increase Drying Rate of Wood

Simpson, William T.
Wood Fiber Sci. 19(1): 9-25; 1987.

The objective of this study was to determine the extent to which laser incising can decrease drying time of wood. Specifically, the effect of hole spacing and diameter were investigated. The time required for 90 percent of total drying to occur was decreased by as much as 70 percent for close hole spacings. As spacing increased, the reduction in drying time decreased until at a spacing of 0.20 inch it was only 5 percent or less. The effect of hole diameter was less well defined.

33. Vacuum Drying Northern Red Oak

Simpson, William T.
Forest Prod. J. 37(1): 35-38; 1987.

Vacuum-drying of lumber is an old idea, and it has usually been written off as uneconomical. Because of this lack of favorable economics, little technical data have been published on vacuum-drying—either fundamental or practical details. The objective of this study is of a practical nature—to determine the drying time and quality of northern red oak dried in one particular type of vacuum-dryer.

pulp, paper, and packaging

34. Predicting Edgewise Compressive Strength

Bormett, David W.
Boxboard Containers. 1986 November: 30-34.

A system is presented and verified as accurate for predicting the edgewise compressive strength of singlewall corrugated fiberboard (ECSB) from the edgewise compressive strength of its paperboards (ECSP). The system links three recent developments from the USDA Forest Products Laboratory: the vacuum-restraint paperboard edgewise compression apparatus (VECA), the routered necked-down ECSB test specimen, and the predictive model of Johnson-Urbanik. The system is not yet applicable to multiwall board.

35. Direct Board-Facing Moisture Measurement

Burns, Stanley G.; Laundrie, James F.
Paperboard Packag. 1986 December: 54-58.

The authors have designed and developed a prototype instrumentation package for direct measurement of moisture content in corrugated container paperboard facings. The system is multichanneled, can be located remotely, and can be used in an electrically noisy environment. The sensors are simple, sturdy, inexpensive, easily applied, and as responsive as paperboard itself to changes in relative humidity and corresponding changes in board moisture content.

36. Measuring the Mechanical Behavior of Paperboard in a Changing Humidity Environment

Gunderson, Dennis E.; Considine, John M.
In: Proceedings, 1986 International process and materials quality evaluation conference; 1986 September 21-24; Atlanta, GA. Atlanta, GA: TAPPI Press; 1986: 245-251.

Both the strength and stability of compressively loaded paperboard are known to be adversely affected by cyclic changes in relative humidity. Current research at the Forest Products Laboratory seeks to observe and explain this phenomenon and to develop a simple, practical test to determine allowable "working loads" in cyclic moisture environments. A new research apparatus has been developed to measure creep strain, stiffness, and strength in constant and changing humidity environments. Early results link cyclic change in relative humidity with significant loss in compressive strength and suggest the existence of a critical load value above which cyclical humidity changes are progressively destructive to the integrity of the web structure. Current efforts are directed toward evaluating the relationship between strength loss, creep load, rate of humidity change, and number of humidity cycles.

37. Buckling of Axially Loaded, Long Rectangular Paperboard Plates

Johnson, Millard W., Jr.; Urbanik, Thomas J.
Wood Fiber Sci. 19(2): 135-146; 1987.

This study examines the elastic buckling of long rectangular plates made of paper and subjected to compressive axial loading. The model is appropriate for the facing and flute components of corrugated fiberboard. Comparing the results obtained assuming fixed edges to those obtained assuming simply supported edges explains how fiberboard strength may vary due to component variations. Comparing the results obtained for nonlinear materials to those obtained for linear materials explains why fiberboard edgewise compressive strength cannot be accurately predicted from only the components' strengths.

38. Disc Separation: Optimization of Contaminant Removal

Klungness, John H.
Tappi J. 70(3): 131-136; 1987.

Disc separation has the potential to more effectively remove nonwettable adhesive contaminants such as hot-melt adhesives and pressure-sensitive adhesives than is possible with conventional separation techniques presently used in industry. In this study, the author optimizes the efficiency and effectiveness of a 152-mm-diameter disc separator for removing these commonly encountered adhesives from a pulp slurry made from corrugated fiberboard sheets. At optimum conditions, the disc separator removed 90.4 percent of the hot-melt adhesives and 86.9 percent of the pressure-sensitive adhesives, respectively, in a single pass. This was accomplished with fiber losses of 7.7 percent and 16.9 percent, respectively. Compared with industrial separation equipment, optimized disc separation removed contaminants more effectively with lower fiber loss.

39. Characterization of Fiberboard Pulp

Myers, Gary C.
Forest Prod. J. 37(2): 30-36; 1987.

Fiberboard pulps were prepared from four species of wood (aspen, eastern white pine, southern yellow pine, and sweetgum), each refined to four drainage rates. These fiberboard pulps were characterized in five ways: (1) drainage rate, (2) screen classification, (3) pulp composition, (4) fiber dimensions, and (5) scanning electron micrographs of fiber surfaces and walls. Refining fiberboard pulps results in a slower drainage rate because the number of fiber bundles and intact fibers decreases, while the number of whole fibers, broken fibers, and fiber fragments increases. Refining shortens fiber length, but has little influence on fiber diameter. During mild refining, debris is removed from the fiber surface, but more severe refining splits and fragments the fiber wall. Results are presented in 10 figures.

40. Device for Longitudinally Compressing Single Pulp Fibers

Sachs, I. B.
Rev. Sci. Instrum. 57(9): 2351-2352; 1986.

Paper and paperboard products are often subjected to edgewise compression loads in use. The basic component of paper and paperboard is the individual pulp fiber. Observance of external changes on the fiber wall should provide information as to how and why pulp fibers fail under compressive load. A fiber compression device was designed for use in the specimen chamber of a scanning electron microscope. This device permits observation of changes in the cell walls of individual pulp fibers while the fiber undergoes longitudinal compressive loading.

41. Retaining Raised Fibrils and Microfibrils on Oak Fiber Surfaces

Sachs, Irving B.
Wood Fiber Sci. 19(2): 196-203; 1987.

Drying of spruce softwood kraft fibers treated with hexamethyldisilazane (HMDS) has been found to: (1) maintain fibrils and microfibrils in a raised position on fiber surfaces, (2) raise fibrils and microfibrils that had been dried down on fiber surfaces, and (3) increase strength properties of handsheets made from dried fiber. The question whether shorter thick-walled hardwood fibers behave similarly is examined in the present study of the effect of HMDS-drying on oak kraft pulp fibers. The effects of HMDS-drying, air-drying, and paper-machine-drying were evaluated by observing the surfaces of refined hardwood kraft pulp fibers. Using scanning electron microscopy, the fiber surfaces of these dried fibers were compared with those of never-dried fiber whose morphology was preserved by critical point drying. In addition, air-dried and paper-machine-dried fibers were examined after rewetting and HMDS-treatment to recover fibrils and microfibrils.

Fundamental Strategy for Control of Retention and Drainage on a Modern Paper Machine

Springer, Allan M.; Noe, Jeffrey S.; Wegner, T. H.
Tappi J. 70(1): 43-45; 1987. (Available from Allan Springer, Paper Science and Engineering Department, Miami University, Oxford, OH 45056. No charge.)

The authors discuss the instrument-based strategy that must be developed to adequately control retention and drainage of contaminants in recycled white water.

Measurements Needed for On-Line Control of Retention and Drainage

Springer, Allan M.; Noe, Jeffrey S.; Wegner, T. H.
Tappi J. 70(4): 125-128; 1987. (Available from Allan M. Springer, Paper Science and Engineering Department, Miami University, Oxford, OH 45056. No charge.)

A strategy for control of retention and drainage was elucidated in a previous article. Two measurements critical to implementation of that strategy are conductivity and total organic carbon. The authors examine these two measurements in some depth.

42. Effect of Pulping Liquor on Drainage Aid Performance with Recycled Fiber

Wegner, T. H.
Tappi J. 70(1): 100-103; 1987.

In this study, this author determines (a) the effects of different types and concentrations of dried pulping liquor on the effectiveness of a cationic polyacrylamide drainage aid, (b) the effectiveness of washing to remove dried pulping liquor from the recycled fiber, and (c) the effects of dried pulping liquor compared to those of never-dried pulping liquor on polyacrylamide effectiveness.

43. Strength and Optical Properties of Chemically Pretreated Aspen Chip Groundwood

Wegner, Theodore H.
Tappi J. 70(5): 119-123; 1987.

Conventionally produced stone groundwood (SGW) and the stone-grinding process are limited by the need to use roundwood and the difficulty in using chemical pretreatment. The author's purpose was (a) to evaluate strength and optical properties of handsheets produced from aspen chip SGW pretreated with three different chemical treatments and (b) to compare strength and optical properties of chip and roundwood SGW. All three chemical pretreatments—cold soda, neutral sulfite, and sodium bisulfite—increased sheet strength properties to strengths equivalent to or higher than those reported in the literature for SGW produced from aspen roundwood.

44. Improvements of Corrugated Fiberboard Wet Properties Through Crosslinking in a Large-Scale Reactor

Young, T. L.; Caulfield, D. F.
Tappi J. 69(12): 71-74; 1986.

The moisture sensitivity of fiberboard, which leads to a loss in strength, stiffness, and dimensional stability, is remedied by a chemical crosslinking treatment developed at our laboratory that uses formaldehyde and sulfur dioxide. The treatment was used to crosslink double-wall corrugated fiberboard in a large-scale, specifically designed reactor. The authors examined the effect of formaldehyde crosslinking on wet stiffness and wet compressive strength of the linerboard component, and on wet compressive strength and dimensional stability of the combined board after 24-hour water soaking. Fiberboard wet-to-dry property ratios increased proportionally with increasing bound formaldehyde content. Results encourage the development and use of crosslinked corrugated fiberboard in structural applications.

structural fiber and particle products

45. Steam Injection Pressing—Large Panel Fabrication with Southern Hardwoods

Geimer, Robert L.; Price, Eddie W.
In: Maloney, Thomas M., ed. Proceedings of the 20th International Particleboard/Composite Materials Symposium; 1986 April 8-10; Pullman, WA. Pullman, WA: Washington State University; 1986: 367-384.

Large 4- by 8-foot panels were made using a steam injection method of pressing. Homogenously constructed flakeboards were fabricated from southern red oak, sweetgum, and a mixture of the two species using both isocyanate and phenolic resins. Isocyanate was especially suited to the process and 1-1/2-inch-thick panels were pressed in less than 150 seconds. Phenolics, on the other hand, were susceptible to dilutions by steaming and required higher temperature to cure.

Chemical Modification of Wood Substance

Rowell, Roger M.
In: Proceedings, Wood technology, chemistry and construction symposium; 1986 October 1-2; Stockholm, Sweden. (Available from Swedish Institute for Wood Technology Research, Box 5073, 10242, Stockholm, Sweden.)

This paper discusses how chemically modifying wood cell wall polymers changes the basic properties of the wood. With the growing markets for reconstituted wood products, the technology developed for solid wood was applied to these products. A new procedure was developed to acetylate flakes that greatly reduced reaction time and simplified the total system. Flakeboards made from acetylated flakes from the new procedure absorbed much less water, both in liquid and vapor tests, swelled at a lower rate and to a lower extent than did control boards. Acetylated flakeboards also showed greatly improved resistance to tunneling bacteria and brown-, white-, and soft-rot fungi and termites.

Structure and Properties of Acetylated Wood I. Changes in the Degree of Crystallinity and Dielectric Properties by Acetylation

Zhao, Guang-Jie; Norimoto, Misato; Tanaka, Fumio; Yamada, Tadashi; Rowell, Roger M.
Mokuzai Gakkaishi (J. Japan Wood Res. Soc.) 33(2): 136-142; 1987. (Available from Wood Research Institute, Kyoto University, Uji, Kyoto 611, Japan.)

Small Sitka spruce (*Picea sitchensis* Carr.) wood specimens were acetylated by immersing them in acetic anhydride for various periods of time at 120°C. Changes in the structure and properties of the treated specimens with weight gains were investigated.

Computer Simulation of Laminated Wood Panel Warping

Suchsland, Otto; McNatt, J. D.
Forest Prod. J. 36(11/12): 16-23; 1986. (Available from Professor Otto Suchsland, Department of Forestry, Michigan State University, 126 Natural Resources Building, East Lansing, MI 48824-1222. No charge.)

The warping of laminated panels in response to moisture content changes is simulated by a computer model based on the assumption that the laminas respond elastically to the developing forces. The computer model is capable of constructing large numbers of laminated panels in which face layers are selected from a large pool of naturally variable veneer sheets. The strong effect of this natural variability on warping is clearly demonstrated. The model is applied to loblolly pine plywood and veneered furniture panels. The sometimes significant warping along the face grain of construction plywood is ascribed to the presence of cross grain, reaction wood, or juvenile wood. Furniture panels appear to be rather warp resistant due to their large overall thickness and the very small veneer thickness. As in construction plywood, the stiffness of face and core material is of relatively small importance.

46. Mechanical Properties and Dimensional Stability of Acetylated Aspen Flakeboard

Youngquist, J. A.; Rowell, R. M.; Krzysik, A.
Holz als Roh- und Werkstoff. 44: 453-457; 1986.

Aspen flakes, reacted with acetic anhydride to approximately 20 percent weight gain, were pressed into flakeboards using a water-soluble phenolic resin. Microphotographs revealed little penetration of the resin into the acetylated wood. Water sorption and thickness swelling are greatly reduced with acetylation; however, internal bond and moduli of rupture and elasticity were also significantly reduced as compared to control boards.

timber requirements and economics

47. Comparison of Isocyanate and Phenol-Formaldehyde Bonding Costs

Harpole, George B.
In: Christiansen, Alfred W.; Gillespie, Robert; Myers, George E.; River, Bryan H., eds. Wood adhesives in 1985: Status and needs: Proceedings 47344 of a conference; 1985 May 14-16; Madison, WI. Madison, WI: Forest Products Research Society; 1986: 42-46.

This paper presents estimates of costs for comparison of structural particleboard production with isocyanate and phenolic binders. Computerized simulations of structural particleboard production were used to assess manufacturing costs, using diverse processing assumptions related to binders. Costs were based on facilities of an efficient size producing 150 million square feet of 7/16-inch-thick panel per year.

48. The United States Woodpulp Industry

McKeever, David B.
USDA Forest Serv. Resour. Bull. FPL-RB-18; 1987.

This report provides government and industry researchers and market analysts a comprehensive review of the woodpulp industry and brings together in a single source information not available elsewhere. The capacity and production of the U.S. woodpulp industry in 1983 are reported by region and woodpulp grade, and trends in capacity and production are analyzed. The estimates of individual mill capacities for 1961, 1965, 1970, and 1974 are derived from published reports. Capacity estimates for 1983 are based on information from a variety of published sources including industry directories, corporate annual reports, trade journals, and association reports. No attempt has been made to identify mills that were idle for less than a year. Annual woodpulp capacity and production, foreign trade, apparent domestic woodpulp consumption, and pulpwood requirements are also examined.

49. Status of Wood Products Use in Nonresidential Construction

Spelter, Henry; Maeglin, Robert; LeVan, Susan
Forest Prod. J. 37(1): 7-12; 1987.

This paper discusses some results of a survey of wood use in nonresidential construction. Nonresidential construction is a large market for building materials, including lumber, laminated beams, plywood, and other panel products. Contractor and builder responses indicate that many perceive wood construction as more expensive than alternatives, wood products as less consistent in quality than other materials, and building codes as limiting the use of wood.

Sources of Productivity Change in the U.S. Forest Products Industries

Steuer, Anne Strees
In: Proceedings, Southern Forest Economics Workers/Midwest Forest Economists 1987 joint annual meeting; 1987 April 8-10; Asheville, NC. (Available from Information, North Central Station, 1992 Folwell Avenue, St. Paul, MN 55108. No charge.)

Productivity growth is an important component of long-term economic growth. It has been estimated that historically, productivity increases have accounted for as much as one-third of the growth rate in the United States. This paper explores the sources of productivity change in the U.S. forest products sector.

50. Research on U.S. Timber and Wood Products Requirements

Stone, Robert N.; Marcin, Thomas C.
In: Papastavrou, Anastassios C.; chairman. Policy analysis for forestry development: Proceedings of the International Union of Forestry Research Organizations international conference, vol. 1; 1984 August 27-31; Thessaloniki, Greece. Thessaloniki, Greece: Forest Research Institute of Thessaloniki; 1984: 121-130.

The National Timber Requirements Work Unit conducts a broad research program to analyze present and prospective consumption of timber and wood products by major market sectors in the United States, and to relate these requirements to the Nation's timber supply and demand situation. Wood consumption studies are conducted for major market sectors such as housing, nonresidential construction, manufacturing, railroads, shipping, and residential fuelwood use.

tropical wood utilization

51. Design for Lumber Dry Kiln Using Solar/Wood Energy in Tropical Latitudes

Tschernitz, J. L.; Simpson, W. T.
Drying Technol. 4(4): 651-670; 1986.

Developing countries with a timber resource that can be manufactured into finished products either for local use or export often lack the capital to build high-cost dry kilns. The low-cost solar/wood energy lumber dry kiln described in this report was designed and tested for such countries where solar dry kilns can be built and operated at low cost.

wood bonding systems

52. Durable Wood Adhesives Based on Carbohydrates

Christiansen, A. W.
In: Christiansen, Alfred W.; Gillespie, Robert; Myers, George E.; River, Bryan H., eds. Wood adhesives in 1985: Status and needs: Proceedings 47344 of a conference; 1985 May 14-16; Madison, WI. Madison, WI: Forest Products Research Society; 1986: 211-226.

Adhesives presently used for exterior-type, wood-based products depend upon petroleum for their starting materials. With the increasing energy needs of an expanding population and the inevitable decline in oil and gas supplies in the long term, the need for alternative adhesive systems from renewable resources is self-evident. The purpose of this investigation was to explore the potential of carbohydrates as constituents in water-resistant adhesives.

53. Bonding Wood Veneer with Carbohydrate-Modified Phenol-Formaldehyde Resins

Conner, Anthony H.; River, Bryan H.; Lorenz, Linda F.
In: Christiansen, Alfred W.; Gillespie, Robert; Myers, George E.; River, Bryan H., eds. Wood adhesives in 1985: Status and needs: Proceedings 47344 of a conference; 1985 May 14-16; Madison, WI. Madison, WI: Forest Products Research Society; 1986: 227-236.

For adhesive self-sufficiency, the wood industry needs new adhesives in which the petroleum-derived component is replaced by a renewable resource. The authors tested partial phenol replacement in phenol-formaldehyde resol-resins by carbohydrates derived from wood. The experiments show that the addition of nonreducing carbohydrates and various polyols does not adversely affect the dry- or wet-shear strength of 2-ply Douglas-fir panels bonded with the modified resins. Reducing carbohydrates, however, cannot be used as the modifier.

54. Carbohydrate Modified Phenol-Formaldehyde Resins

Conner, Anthony H.; River, Bryan H.; Lorenz, Linda F.
J. Wood Chem. Technol. 6(4): 591-613; 1986.

Results are reported of research, initiated in January 1983, to determine whether or not wood-derived carbohydrates, carbohydrate derivatives, and other polyhydric alcohols can be used to modify phenolic plywood adhesives by replacing part of the phenol-formaldehyde resin. Specifically, this research was to demonstrate that a water prehydrolysate of wood could be used to modify phenol-formaldehyde resol-resins. The dry- and wet-shear strength of two-ply Douglas-fir veneers bonded with various formulations were used to indicate resin adequacy. Preliminary research was also conducted to determine if the carbohydrate component is chemically incorporated into the final cured resin.

55. Lignin in Durable Adhesives for Wood: Part I. Evaluation of Lignin-Aldehyde Reactivity

Gillespie, Robert H.
In: Christiansen, Alfred W.; Gillespie, Robert; Myers, George E.; River, Bryan H., eds. Wood adhesives in 1985: Status and needs: Proceedings 47344 of a conference; 1985 May 14-16; Madison, WI. Madison, WI: Forest Products Research Society; 1986: 170-188.

The purpose of this investigation was to evaluate the formaldehyde reactivity of different lignin materials and to demonstrate how they might be used in thermosetting resin systems of value in durable adhesives for wood.

56. Organic Chemical Structure Determinations of Wood Adhesives by Solid-State NMR

Maciel, Gary E.; Chuang, I-Ssuer; Hatfield, Galen R.; Myers, George E.
In: Christiansen, Alfred W.; Gillespie, Robert; Myers, George E.; River, Bryan H., eds. Wood adhesives in 1985: Status and needs: Proceedings 47344 of a conference; 1985 May 14-16; Madison, WI. Madison, WI: Forest Products Research Society; 1986: 257-264.

This paper presents an overview of the application of CP/MAS NMR techniques, especially with ^{13}C, to the study of solid resins. In this overview the authors focus on work carried out at Colorado State University and will attempt to provide a perspective on the directions in which solid-state NMR should be useful in the future in understanding the chemistry of resins and wood adhesives.

57. Resin Hydrolysis and Mechanisms of Formaldehyde Release from Bonded Wood Products

Myers, George E.
In: Christiansen, Alfred W.; Gillespie, Robert; Myers, George E.; River, Bryan H., eds. Wood adhesives in 1985: Status and needs: Proceedings 47344 of a conference; 1985 May 14-16; Madison, WI. Madison, WI: Forest Products Research Society; 1986: 119-156.

In this paper the author examines the available evidence for and against the influence of urea-formaldehyde (UF) resin hydrolysis on formaldehyde emission from UF-bonded wood products. That evidence includes literature reports from 1950 through 1984 as well as unpublished results from his own recent studies.

58. Enhanced Wood Bond Strength Through Surface Treatment

Young, R. A.; Krzysik, A.; Fujita, M.; Kelley, S. S.; Rammon, R. M.; River, B. H.; Gillespie, R. H.
In: Christiansen, Alfred W.; Gillespie, Robert; Myers, George E.; River, Bryan H., eds. Wood adhesives in 1985: Status and needs: Proceedings 47344 of a conference; 1985 May 14-16; Madison, WI. Madison, WI: Forest Products Research Society; 1986: 237-254.

A description of wood surfaces is given and previous work on surface activation and characterization is reviewed. Wood surfaces can be activated for wood bonding by several mechanisms including oxidation, free radical formation, acidification and alkalation. The treatments appear to open-up and plasticize the wood surface, remove extractives, making the surface more wettable, enhance the reactivity of the solid wood polymer components, and form low molecular weight chemicals which may affect bonding.

59. Resin Distribution in Hardboard: Evaluated by Internal Bond Strength and Fluorescence Microscopy

Youngquist, J. A.; Myers, G. C.; Murmanis, L. L.
Wood Fiber Sci. 19(2): 215-224; 1987.

Using fluorescence microscopical techniques, we found that differences in resin distribution can be clearly detected. The authors observed that decreasing the resin solids content, mechanically increasing the fiber rubbing action with the resin, and changing the rate of resin application were effective ways for improving resin distribution in hardboard furnish. The microscopic technique also showed that uniform distribution of the resin throughout the hardboard produced boards with the highest internal bond strengths.

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Clark C. Heritage, an early leader in pulp and paper research at FPL and later director of wood products research for Weyerhaeuser. His legacy funded development of the Heritage Series (Photo courtesy of Weyerhaeuser Company)

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Selected Publications from the U.S. Government Printing Office

The following publications written by scientists at the Forest Products Laboratory are available for sale through the Superintendent of Documents, U.S. Government Printing Office:

Finishing Wood Exteriors:
Selection, Application, and Maintenance

Cassens, Daniel L.; Feist, William C.
Agriculture Handboook 647 (1986), 56 p.
U.S. Department of Agriculture
Stock number 001-000-04450-8, $3.25

This handbook give the characteristics and proper application of finishes to the different solid and reconstituted wood products now available, focusing on the different kinds of wood, manufacturing and construction practices that affect surfaces to be finished and the ways in which various types of finishes interact with the effects of those characteristics and practices.

Construction Guides for Exposed Wood Decks

Anderson, L. O.; Heebink, T. B.; Oviatt, A. E.
Agriculture Handbook 432 (1972), 78 p.
U.S. Department of Agriculture
Stock number 001-000-02577-5, $5.00

This handbook covers the design, finishing, and treatment of outdoor wood decks to insure user satisfaction. Both good and poor construction details are amply illustrated for the benefit of architects, builders, and homeowners.

New Life for Old Dwellings:
Appraisal and Rehabilitation

Sherwood, Gerald E.
Agriculture Handbook 41 (1975), 99 p.
U.S. Department of Agriculture
Stock number 001-000-02988-6, $5.50

Older wood-frame houses can often be rehabilitated at a lower cost than new construction and with desirable material savings. The appraisal section deals with the suitability of such dwellings for rehabilitation and the rehabilitation portion suggests how to plan and accomplish such changes.

Wood Decay in Houses:
How to Prevent and Control It

Forest Service
Home and Garden Bulletin 73 (revised 1986), 25 p.
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Seasoned, properly used wood is a dependable building material, with decay causing little damage. This bulletin contains general safeguards, methods for protecting woodwork close to the ground, methods for safeguarding parts of houses exposed to rain, methods for protecting new types of building materials, and general methods for maintaining houses.

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